Science
Module 11

High School Biology I
Life Science: Energy Flow

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Interdependence – All life is interdependent and interacts with the environment.
- Flow of Matter and Energy – Matter cycles and energy flows through the biosphere.

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to High School Biology I – Life Science: Energy Flow and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Connecting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and related Alternate Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are

basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs and UCs for Life Science: Energy Flow. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Science Academic Standards and Related AATs and UCs [1]

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
Interdependence – All life is interdependent and interacts with the environment.		
3210.2.2 Interpret the relationship between environmental factors and fluctuations in population size.	Recognize the relationship between population size and available resources for food and shelter (e.g., a graphical representation).	Identify food and shelter needs for Tennessee wildlife.
Flow of Matter and Energy – Matter cycles and energy flows through the biosphere.		
3210.3.1 Interpret a diagram that illustrates energy flow in an ecosystem.	Use a graphical representation to identify the changes in the amount of matter or energy as it travels through a food web.	Recognize that there are generally fewer organisms at higher levels of a food web (e.g., a graphical representation).
3210.3.3 Compare and contrast photosynthesis and cellular respiration in terms of energy transformation.	Match photosynthesis to the storing of energy and respiration to the release of stored energy.	Understand oxygen allows animal cells to produce energy from food.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts, rather it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K – 12. These practices provide students an opportunity to learn

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs and UCs listed in Table 1.

science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. See Section VI. Universal Design for Learning Suggestions for support ideas. The following are eight science and engineering practices (National Research Council, 2012) with added examples.

Science Practices

- Asking questions (for science) and defining problems (for engineering).
  Examples: How does the availability of food and shelter affect the population and reproduction of a species native to Tennessee (e.g., Northern Pine Snake, Bog Turtle, Golden Eagle, etc.) How does access to food for humans affect black bears? Why are plants essential to my nutrient needs? How is energy transferred from plants or animals on one level of an energy pyramid to animals on the next level?

- Developing and using models.
  Examples: Create a model of an energy pyramid using plants and animals from a local ecosystem to generate predictions and explanations for energy flow in an ecosystem. Analyze a predator/prey graph to explain the relationship between population size and number of predators. Create a model illustrating the process of photosynthesis and cellular respiration that makes its central features explicit and visible.

- Planning and carrying out investigations.
  Examples: Conduct an investigation on the use of glucose in cellular respiration. Conduct an online lab investigation of the relationship between predators and prey.

- Analyzing and interpreting data.
  Examples: Analyze data to determine the impact of removal of a species, addition of a non-native species, or a drought on a specific population. Analyze population changes gathered from historical data or simulations of ecosystems at different scales. Demonstrate precision in use of terminology, units, and scales.

- Using mathematics and computational thinking.
  Examples: Measure the amount of water that enters a pipette to determine the amount of oxygen consumed through cellular respiration (see lab investigations in Science Practice Resources). Compute the amount of energy in each level of the energy pyramid of a given ecosystem. Calculate how much carbon plants store through photosynthesis. Use mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of ecosystem factors to identify changes over time in the numbers and types of organisms in ecosystems.

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain how cutting down 30 acres of woods to build a subdivision affects the population of deer living in the woods. Design a solution to maintain the food and shelter needed for a specific species of animal when building a city park. Explain how the flow of matter into and out of cells must be driven by the energy captured by photosynthesis or obtained by taking in food and released by respiration.

- Engaging in argument from evidence.
  Examples: Use reasoning and evidence to argue for regulations (e.g., bear proofing garbage cans, proper handling of restaurant grease, etc.) to decrease black bear access to food for humans. Use

evidence gathered about photosynthesis and cellular respiration to argue the importance of plants when planning for a new city development. Use reasoning to connect evidence showing that energy inputs to cells occur either by photosynthesis or by taking in food. Present a reasoned argument based on evidence, demonstrating understanding of underlying scientific concepts.

- Obtaining, evaluating, and communicating information.

  Examples: Interpret data showing the decline of a native species in a community and communicate in a letter or presentation to a community leader. Effectively communicate information on the food and shelter needs of Tennessee wildlife to a city planner or in a letter to the editor. Describe the flow of energy upward between organisms and their environment. Select appropriate ways of presenting qualitative and quantitative findings.

Science Practices Resources[2]

This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school.
http://www.justsciencenow.com/inquiry/

- These sites provide energy pyramid, biomass pyramid, and food web models:
  - http://www.cas.miamioh.edu/scienceforohio/wetlands/images/day3a.pdf
  - http://seanrgrant.yolasite.com/resources/5136_interactive%20reader.pdf
  - http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/environment/populationsandpyramidsrev2.shtml
  - https://www.biologycorner.com/worksheets/food_web_label.html
  - http://www.cleverwraps.com/food-web-worksheet-high-school
- These sites provide online lab investigations on predator/prey relationships:
  - http://www.bapp.org/puma-prey-lab
  - http://www.clexchange.org/curriculum/complexsystems/oscillation/Oscillation_PredpreyA.asp
- These sites include photosynthesis investigations:
  - http://serc.carleton.edu/sp/mnstep/activities/35653.html
  - http://igbiologyy.blogspot.com/2012/12/photosynthesis-investigations.html
  - http://www.bbc.co.uk/education/guides/zpwmxnb/revision/4

[2] The resources in this module may change over time and no longer be available.

Section III

Connecting Concepts

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Connecting Concepts are a common link between multiple standards and units of study. The Connecting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. For example, students may understand that a system is a group of related parts that make up a whole which can carry out functions its individual parts cannot. This concept connects the idea of an ecosystem, the process of photosynthesis, and the process of cellular respiration. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., understanding energy driving the motion or cycling of matter in health class).

Teaching Connecting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Connecting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., Illustrate the pattern of energy flow from the lowest level to the highest level.),
- critical features (e.g., Emphasize the importance of plants in providing oxygen.),
- big ideas (e.g., Highlight the similarities and differences between photosynthesis and cellular respiration.), and
- relationships (e.g., Show the relationship between predator and prey regarding population size.).

For example, when learning about relationships between population size and available resources for food, demonstrate the effect of removing prey or removing predators. In addition, build connections between familiar and new information (e.g., Relate instruction about relationships in the ecosystem to the relationship between the amount of food and the number of people in the world. Compare the process of cellular respiration to the burning of fossil fuels).

Following are **Connecting Concepts** for this Content Module – Life Science: Energy Flow.

Understand

Patterns

- Patterns can be used to determine similarities and differences.
- Patterns in rates of change and cycles can be used to make predictions.
- Patterns can be observed and used as evidence.

- Patterns can be used to identify cause-and-effect relationships.

Cause and Effect

- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change.

Scale, Proportion, and Quantity

- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight, time, temperature, and volume.
- Models using scale can be used to study systems that are too large or too small.

Systems and System Models

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- System parts work together.

Structure and Function

- Different materials have different substructures, which can sometimes be observed.
- Substructures of different materials have shapes and parts that serve functions.
- The function of complex and microscopic structures and systems depends on the shapes, composition, and relationships among their parts.

Energy and Matter

- Objects may break into smaller pieces, can be put back together, and may change shape.
- Matter is made of particles and energy that can be transferred in various ways and between objects.
- Energy drives the motion and/or cycling of matter.

Stability and Change

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Food molecules and oxygen transfer energy to the cell to sustain life's processes, including the maintenance of body temperature.

Connecting Concept Resources:

- Grant Wiggins talks about "big ideas" in this article. http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99
- A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information. http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
- Teacher Vision provides ten science graphic organizers that are free and printable. https://www.teachervision.com/graphic-organizers/science/52539.html
- Utah Education Network provides a variety of student interactives for grades seven through twelve. http://www.uen.org/7-12interactives/science.shtml

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., energy flow) and in the context of the specific content (e.g., Teach the terms "solar energy," "producers," "primary consumers," "herbivores," "predators," and "carnivores" in the context of energy flow.).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize a variety of animals, plants, organisms, and activities. For example, understanding the meaning of the word "molecule" helps students understand the word during instruction or conversation on photosynthesis, cellular respiration, etc. The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words (e.g., energy transformation) connect to general words, such as "energy," "molecule," "glucose," etc. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three through eight; refer to the TN science standards for grade-specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., a producer is a plant that turns solar energy into nutrition for animals.) and an example of the word (e.g., Lettuce is a producer rabbits eat for nutrition.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Population density is the number of animals living in a certain area.) and a possible connection to a general vocabulary word (e.g., A population dense area can cause the spread of diseases.).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should be able to identify chlorophyll on a model of photosynthesis or describe it as the green in plants that is necessary for photosynthesis.

Table 2. General Vocabulary Words

General Vocabulary – words that generalize different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., food – anything that gives nutrients to a living being.).			
• biomass	• disease	• herbivore	• predator/predation
• carbon dioxide	• drought	• invasive	• prey
• carnivore	• earthquake	• life expectancy	• producer
• cell	• energy	• molecule	• resources
• chemical reaction	• environment	• nutrient	• shelter

• competition	• food	• organelles	• species
• consumer	• glucose	• oxygen	• sunlight
• death rate	• growth rate	• pollution	• water
• decomposer	• habitat	• population	

Table 3. Specific Content Words

Specific Content Words - words that specify a particular thing (e.g., ATP) or phenomenon (e.g., carrying capacity).

Describe the word and when possible make the connection to a Connecting Concept (e.g., An energy pyramid is a model that shows the energy flow in an ecosystem. An energy pyramid shows how matter is made of particles and energy that can be transferred through plants and animals within an ecosystem.)

• aerobic respiration	• deforestation	• food web
• ATP	• density dependent factors	• limiting factor
• biomass	• density independent factors	• mitochondria
• carrying capacity	• ecosystem	• photosynthesis
• cellular respiration	• energy flow	• population density
• chemical bonds	• energy pyramid	• solar/light energy
• chemical energy	• energy transfer	• trophic level
• chlorophyll	• energy transformation	
• chloroplasts	• food chain pyramid	

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)[3]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	Provide a description and an example of habitat, "A habitat is the place a plant or animal normally lives."
Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.	Have students name a familiar animal and tell whether it is a herbivore or carnivore (verbally or using an alternative and augmentative communication [AAC] system).
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a multimedia graphic organizer in which each word(s) has a link to a related video. See Figure 1. Science for an example. • Have students view words paired with pictures and recorded definitions:

Ideas	Examples
	o limiting factors (e.g., https://quizlet.com/120900738/limiting-factorsvocabulary-flash-cards/), o energy pyramid (e.g., https://quizlet.com/7756291/energy-pyramid-vocab-flash-cards/), and o cellular respiration (e.g., https://quizlet.com/154903368/cellular-respiration-flash-cards/).
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Expose students to vocabulary by incorporating it into daily activities such as talking about classroom or school plants and how they are producers and how we, our pets, and other animals are consumers. • Read books or watch videos related to the vocabulary and concepts: o Consumers and Producers (e.g., http://bookbuilder.cast.org/view.php?op=view&book=89265&page=1) and o food chains and webs (e.g., http://bookbuilder.cast.org/view.php?op=view&book=7077&page=1). • Have students create a word cloud (e.g., https://tagul.com/create).
Ask students to discuss the vocabulary words with each other.	• Have students share a definition or description of a word and have others guess the word. • Have students share their representations (e.g., drawings or pictures) of a word with each other.
Play vocabulary word games with students.	• Have students participate in an activity to understand terms such as carrying capacity, habitat, limiting factor, management, and population (e.g., https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5073081.pdf). • Have students work with an interactive word wall (e.g.,http://nstacommunities.org/blog/2013/10/16/putting-science-words-on-the-wall/).

Ideas	Examples
Have students watch a dramatization or have them act out the vocabulary term.	Have students use charades, possibly with props, to describe vocabulary terms.

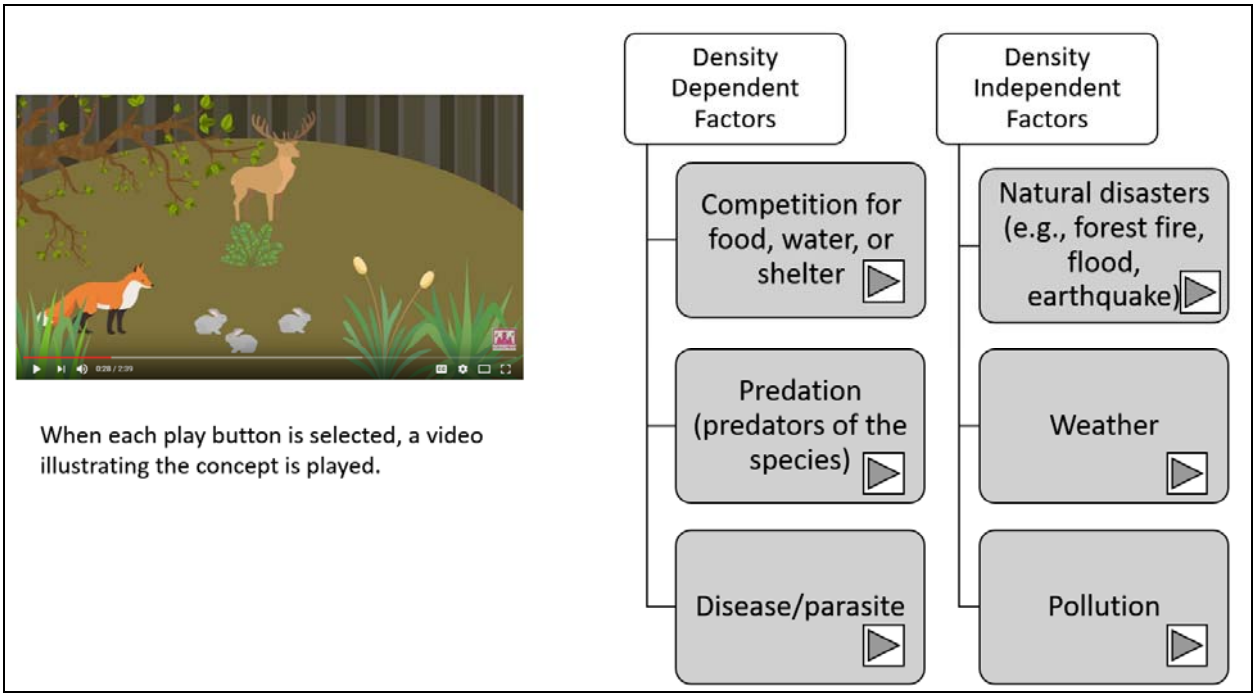
[3] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students complete a multimedia graphic organizer in which a video illustrating each term is played when the arrow/play button is selected (see Figure 1). The activity can be modified as needed for individual students. For example, one student may use an adapted mouse to play the video for each term while another student may use eyegaze to direct a peer or adult to play a certain video. Another student may use a mouseover to hear the term and to locate the play button. Two National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

Figure 1. Science Multimedia Graphic Organizer



Vocabulary Resources:

Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/

Text Project provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the

Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/

This site provides effective strategies for teaching science vocabulary. http://www.learnnc.org/lp/pages/7079

The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

This site provides a wide range of science graphic organizers, including some that are vocabulary specific. http://www.actedu.in/wp-content/uploads/2016/03/Science-Graphic-Organizers.pdf

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the AATs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Interdependence – All life is interdependent and interacts with the environment.

Content:

- Animals need food and shelter to grow and reproduce.
- Density dependent limiting factors include:
  - competition for resources (e.g., food, water, and shelter),
  - predation (e.g., percentage of predators and prey), and
  - diseases.
- Density independent limiting factors include:
  - weather,
  - natural disasters (e.g., floods, earthquakes, droughts),
  - deforestation, and
  - pollution.
- Ecosystems have carrying capacities resulting from biotic and abiotic factors.
- Producers and consumers have specific roles in an ecosystem.
- Herbivores, carnivores, omnivores, scavengers, and decomposers have specific roles in an ecosystem.
- Ecological pyramids depict biomass, energy flow, and numbers of organisms.

Flow of Matter and Energy – Matter cycles and energy flows through the biosphere.

Content:

- Matter cycles in an ecosystem.
- Energy flows through solar (light) energy → producers → primary consumers (herbivores) → secondary consumers (predators/carnivores) → tertiary consumers (top of the food chain predators).
- Decomposers break down wastes and dead organisms, returning nutrients to the soil.
- The amount of energy decreases as it is used by organisms as it flows from producers to top predators (i.e., the top of the energy pyramid).
- A food web consists of all of the food chains in an ecosystem.
- There are generally fewer organisms and less biomass at higher levels of a food web.
- Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels.
- Graphical representations of energy pyramids, food chain pyramids, and food webs demonstrate energy and biomass distribution.
- Energy transformation occurs during photosynthesis as a plant converts light energy from the sun into chemical energy in the form of glucose molecules.
- Energy transformation occurs during cellular respiration when the chemical energy of stored glucose molecules is released and converted to ATP molecules.
- Photosynthesis uses carbon dioxide, water, and sunlight to create glucose molecules in chloroplast cells.
- Sugar molecules provide both energy for cellular work and building blocks for other organic molecules.
- Cellular respiration produces ATP in mitochondria (rod-shaped organelles). Cellular respiration occurs in both plants and animals.
- Animal cells use oxygen, through aerobic respiration, to convert glucose molecules into ATP molecules.
- Photosynthesis and cellular respiration provide most of the energy for life processes.

Unit Content Resources:

Environmental Factors and Fluctuations in Population Size

- These sites provide information on Tennessee wildlife needs. https://www.tn.gov/twra/topic/species-list
- https://www.fws.gov/asheville/pdfs/Curricula-TNbackgroundinformation.pdf
- This Prezi slide show provides information and videos on environmental factors and population fluctuations. https://prezi.com/gkzvobrzxegn/factors-that-cause-fluctuations-in-populations/
- Khan Academy has a video explaining population regulation. https://www.khanacademy.org/science/biology/ecology/population-growth-and-regulation/v/density-dependent-and-density-independent-population-regulation

- Nature Works provides information on natural and human impacts on wildlife. http://www.nhptv.org/natureworks/nwep16b.htm
- This site provides a description of density dependent and density independent limiting factors on size or growth of a population. http://death-valley-ecology.weebly.com/density-dependent-and-independent-limiting-factors.html
- This site provides information and activities on limiting factors on population size. http://www.mchs154.org/files/Objective%232ActivitiesPopGrowth.docx
- This site provides a lesson on the relationship between organisms and the physical environment. https://www.biologycorner.com/worksheets/kaibab.html
- This site provides information on the energy pyramid, photosynthesis, and cellular respiration. https://www.learner.org/courses/essential/life/session7/closer.html

Energy Flow in an Ecosystem

- Annenberg Learner has an online textbook with information on energy flow through the ecosystems. https://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=3
- Shmoop provides information on energy flow including an energy flow pyramid and a food web. http://www.shmoop.com/ecology/ecosystem-energy-flow.html
- This site presents a video on an energy pyramid and explains how the amount of energy decreases at each higher level of the pyramid. https://www.youtube.com/watch?v=CReZd9OHEfs
- National Geographic provides information on food webs. http://nationalgeographic.org/encyclopedia/food-web/
- This site provides information on pyramids of biomass, including sample pyramids. http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/environment/populationsandpyramidsrev2.shtml
- This site provides an investigation on energy flow through an ecosystem. http://docplayer.net/13549573-7-energy-flow-through-an-ecosystem-investigation-2-c-l-a-s-s-se-s-s-i-o-n-s.html
- Serendip provides an activity-based lesson plan on energy flow. http://serendip.brynmawr.edu/exchange/bioactivities/foodweb

Photosynthesis and Cellular Respiration

- This Prezi presentation provides a Venn diagram comparing photosynthesis and cellular respiration. https://prezi.com/--4zwz3buu2s/spi-321033/
- Study.com provides information on energy transformation. http://study.com/academy/lesson/energy-transformation-photosynthesis-vs-cellular-respiration.html#lesson
- This site has information and a graphic about energy cycle in living things. http://hyperphysics.phy-astr.gsu.edu/hbase/Biology/enercyc.html
- This site details how to construct a 3-D model representing glucose molecule photosynthesis. http://www.perkinselearning.org/accessible-science/building-organic-molecule

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization.

Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for these needs:

V = visually impaired (low vision, blind, or deaf-blind)
H = hearing impaired (deaf, hard of hearing, or deaf-blind)
P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	**Examples**

Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Conduct a population ecology lab using hands-on activities (e.g., http://www.biologyjunction.com/PopulationEcologyLab.doc). Adapt by using larger and less crunchable materials. P Mark captured "fish" by replacing with similar size materials using one to one correspondence. **V** Present a food web using pictures and representations of animals (e.g., https://www.pinterest.com/pin/568931365400253435/). **V** Have students listen to a podcast on factors influencing a decrease in population of Monarch butterflies (e.g., http://scienceunderground.org/short-podcast/saving-monarch-butterflies/). **V** Conduct a kinesthetic activity on cellular respiration (e.g., http://www.perkinselearning.org/accessible-science/cellular-respiration-kinesthetic-activity).
Model content through pictures, dramatization, videos, etc.	Watch videos on: • food chains (e.g., https://www.youtube.com/watch?v=MuKs9o1s8h8) and • Photosynthesis and cellular respiration (e.g., https://www.youtube.com/watch?v=JEnjph9miK4). Provide visuals (e.g., energy pyramid or graph showing relationship between population size and resources) when explaining a concept (e.g., energy flow or competition) or steps in a process (e.g., photosynthesis or cellular respiration). **H**
Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures).	Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Present the food chain using an interactive model based on nesting dolls (e.g., http://finallyinfirst.blogspot.com/2011/10/food-chain-and-freebies.html). Present a model of photosynthesis and cellular respiration (e.g., approximately halfway down the page on https://www.exploringnature.org/db/view/1045).
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information to reduce text difficulty and length (e.g., http://textcompactor.com/) and write or type with a bold and plain font (e.g., Verdana, 18 pt. font) with good spacing between lines (e.g., 1.5 vs. single spacing). **V** Provide digital texts with built-in text to speech software (e.g., photosynthesis and cellular respiration, http://bookbuilder.cast.org/view.php?op=view&book=109552&pag

	e=1 and a food web, http://bookbuilder.cast.org/view.php?op=view&book=89446&page=1). **V** Use an adapted mouse to scroll and turn pages. **P**
Teach information using songs.	Have students listen to a song about the food chain (e.g., https://www.youtube.com/watch?v=ttpNGJcpJ68 or https://www.youtube.com/watch?v=xGSZ-zMcigo). Have students play the songs using adapted switch. **P**

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	**Examples**
Use assistive technology to allow the student to interact with the instructional materials and content.	Have students use a text reader to read text about energy flow (e.g., http://www.ck12.org/Earth-Science/Flow-of-Energy-in-Ecosystems/lesson/Flow-of-Energy-in-Ecosystems-MS-ES/). **V** Have students work with a digital or online graphing program (e.g., https://nces.ed.gov/nceskids/createagraph/default.aspx?ID=3f186598475d4b55852050b3ba048174). **V** Have students use a drag-and-drop food web game (e.g., http://coolclassroom.org/cool_windows/home.html).
Present instructional materials in a manner that provides access.	Place printed text and pictures on a slant board. **V/P** Provide a paper stabilizer (e.g., removable tape or glue, nonslip map, clipboard, etc.) to prevent the paper from moving when the student is drawing, writing, reading, or pasting. **P** Label models with high contrast or tactile print (e.g., http://www.visionaware.org/info/everyday-living/home-modification-/labeling-and-marking/125). **V** Provide a USB microscope that transfers the image to the computer screen or an online microscope activity (e.g., http://www.pbslearningmedia.org/resource/f4f6097a-807f-4488-b874-0bae0d8446c8/microscope-activity/en/). **V/P**
Provide voice output devices for students to select an answer.	Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. **P** Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then select the correct answer. **V/P** Ask questions that can be answered with yes/no or with answer choices.
Provide simulation activities.	Have students view or participate in a simulation on: • rabbit population by season (e.g., https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=380), • factors affecting wolf populations (e.g., https://www.wolfquest.org/classroom_activities.php#return_gray), • food chains (e.g., https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=381), and • food webs (e.g., https://www.learner.org/courses/envsci/interactives/ecology/index.php).

Create a digital graphic organizer that allows drag-and-drop.	Have students drag and drop digital pictures of animals onto the correct level of an energy pyramid. Use a screen reader and an adapted mouse. **V/P** Have students use an assistive technology tool when writing a science lab report (e.g., http://sciencewriter.cast.org/welcome).

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule and visual timer.	Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break. Use a first/then schedule (e.g., http://www.autismclassroomresources.com/visual-schedule-series-first-then/).
Vary the challenge and amount of information presented at a time.	Begin with having students identify local or familiar animals within an ecosystem. Then have the students identify the types of foods the animals eat. Finally, introduce the concept of an energy pyramid.
Make connections to topics or activities that are motivating.	Use animals that are motivating to the students (e.g., zoo animals, aquarium fish, etc.). Have students watch an animal cam of animals used in instruction (e.g., http://www.apl.tv/).
Allow choices as possible.	Allow students to choose seating option (e.g., chair, stool, floor, exercise ball, etc.) Allow students to use preferred communication (e.g., high-tech device, low-tech device, gestures, etc.) to answer questions or participate in class discussion.
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when working on an animal competition activity.
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Scaffold instruction on using self-regulation skills (e.g., modeling, cueing, fading support).

UDL Resources

The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org

The UDL Curriculum Toolkit provides two applications for science. http://udl-toolkit.cast.org/p/applications/l1

Perkins School for the Blind provides tips for making science accessible. http://www.perkinselearning.org/accessible-science/getting-started

This Perkins School for the Blind video, 20 minutes long, describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec

Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units.
www.symbaloo.com

This site provides a brief description of Symbaloo and multiple ways to use the online tool. https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/

Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices.
http://www.perkinselearning.org/videos/webcast/tangible-symbols

DeafTEC has a Lab Sciences ASL video dictionary. https://www.deaftec.org/resources/stem-signs/lab-sciences

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematic skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., discussing topics with friends) or understand the concepts (e.g., while listening to the news). Sign ASL STEM terms to provide students with vocabulary needed for science labs and future employment.	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Provide information through reading books and articles on science concepts while working on reading comprehension.	Provide practice on communication skills when students are answering questions or telling about the book or article.
Mathematics	Teach data collection, graphing, and analyzing results during investigations. Identify appropriate dependent and independent variables together with those to be kept unchanged.	Provide practice on number identification, sequence, relative quantity or size (e.g., which is more?), etc.
Age-Appropriate Social Skills	Make connections between the Connecting Concepts and real-life experiences showing how they can help students make decisions (e.g., understanding that they are part of a system and what each person does within the system affects the system).	Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills. With increasing independence, apply scientific analytical thinking skills working with less familiar and more complex contexts.	Use positive behavior supports to encourage and reinforce independent work skills.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when working on the content.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science and social studies concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a map to illustrate location of key countries would not need state lines and capital cities and may not need all the surrounding countries.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., line that indicates a body of water), and remove any that are not.
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a pencil, an example of goods, with a pencil).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science and social studies.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections in a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper – print
- Thermoform

Textured shapes can be made from:

- Sticky back textured papers found at craft stores
- Corrugated cardboard
- Fabric with texture (e.g., corduroy, denim)
- Silk leaves
- Cork
- Felt
- Vinyl
- Mesh tape (used for drywall)
- Sandpaper

Raised lines can be made from:

- Glue (best not to use water-based glue)
- Wax pipe cleaners

Resources

Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided basic principles for Preparing Tactile Graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics

Perkins School for the Blind has short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

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Picture Citations

https://www.youtube.com/watch?v=DwR2zDR0-gQ Creative Commons Attribution license (reuse allowed)

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